# AN ANNOTATED SUMMARY OF RECENT LITERATURE ON THE EFFECTS OF HUMAN DISTURBANCE ON CARIBOU

STEVE MOORE

DEPARTMENT OF RENEWABLE RESOURCES

GOVERNMENT OF THE NORTHWEST TERRITORIES

YELLOWKNIFE, NWT

1987

Northwest Territories Renewable Resources

File Report No. 62

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# INTRODUCTION

This annotated summary cites journals, published reports, and unpublished reports which address the response of caribou to industrial development. Pertinent material, published between 1980 and 1986, was selected for two reasons. First, literature prior to 1980 focused on predicting the impacts of disturbance, whereas recent literature examines present and post-disturbance effects. The primary distinction between pre- and post-development is that the latter affords resource managers an opportunity to examine the significance of an impact, while the former attempts to assess potential hazards from usually limited baseline data sources. Secondly, the disturbance literature prior to 1980 has been extensively researched and compiled by Williams et al. (1983)[1].

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[1]T.M. Williams, M. Raddi, M. Bradley and D.C. Heard. 1983. Beverly and Kaminuriak barren-ground caribou herds: an annotated bibliography. N.W.T. Wild. Serv. Manuscript Rep. 111 pp.

# ANNOTATIONS

Bergerud, A.T., R.D. Jakimchuk and D.R. Carruthers. 1984. The buffalo of the north: caribou (Rangifer tarandus) and human development. Arctic 37(1): 7-22.

This paper examines human impacts on the demography, movement and behaviour of a number of caribou herds: the Porcupine, Nelchina, Central Arctic, Fortymile, Kaminuriak, herds in British Columbia and Newfoundland, and the Snohetta herd in Norway. These herds were selected because they have been exposed to industrial development and/or roads, habitat modification, manipulation of predator populations, and because demographic baseline data exist. The objective was to examine the demographic response of these herds to disturbance over a long period of time, rather than using correlation reasoning which links response to a particular impact over a short period of time.

## Porcupine Herd

Over the past 20 years the Porcupine herd has remained stable (100,000 to 110,000). Yearling recruitment from 1971 to 1980 was 10 to 11% and fall calf counts demonstrated similar stability. Range size has remained consistent since 1971, averaging 240,000 $km^2$. The Dempster Highway, constructed in part during the 1960s, bisects portions of the herd's winter range. Additional construction during 1976 transected a major migration route. A five-mile, no-hunting corridor was implemented in 1978. The Porcupine herd continues

to use its winter ranges despite having to cross the highway.

## Nelchina Herd

The first systematic census on the Nelchina Herd was completed in 1955. The population estimate was 40,000. Predator control was implemented resulting in a calf survival rate greater than 20%. By 1963 the herd had increased to 71,000 and expanded its range across the Richardson Highway. By 1972-73 the population declined to 10,000, due to increases in wolf numbers and hunting pressure, and a decrease in calf survival; however, caribou continued to cross the Denali, Taylor, Glenn and Richardson highways. The herd continued to decline and by 1976 caribou hunting was closed. Restricted hunting and a wolf control program was implemented in 1977. The herd increased to 20,730 by 1981; calf percentages have remained at 18% since 1976. The Trans-Alaska oil pipeline was constructed adjacent to the Richardson Highway during the mid-1970s. Herd size continued to increase after construction.

## Fortymile Herd

The population and range size of the Fortymile Herd have fluctuated dramatically. Previous studies suggest that the limiting factors in population growth are hunting and predation. These limiting factors exceed recruitment.

The Steese, Alaska and Taylor highways all bisect various portions of their range, which historically facilitated access to hunters. None of the documented studies provide evidence of a barrier effect or of range abandonment caused by the roads or hunting pressure.

## Central Arctic Herd

Development of Prudhoe Bay has resulted in concern about the impact of development on the Western Arctic Herd and the Central Arctic Herd inhabiting the North Slope. Although both herds declined during the early 1970s, they have consistently increased since 1976.

Previous studies demonstrate "abnormalities" in herd distribution and composition along the Trans-Alaska Pipeline System. This has been interpreted as herd "fracturing". However, during the past eight years of research on this herd, this effect has not been demonstrated and the herd continues to expand.

## British Columbia Herd

The woodland caribou of British Columbia have been declining since the early 1970s. The decline of herds in northern British Columbia (north of Prince George) has been attributed to heavy calf predation and the overharvesting of adults. The herds found in the south (south of Prince George) are believed to have

declined in response to overharvesting and habitat destruction. The Yellowhead highway and a nearby railroad do not appear to act as barriers to movement.

Newfoundland Herds

Considerable human disturbance, in the form of timber harvesting and construction of two major highways, has occured in Newfoundland on the woodland caribou range. In addition, a railway was constructed during the 1890s which also bisected the caribou range. Despite all of these developments, caribou remain productive and continue to cross the railway and roads.

Kaminuriak Herd

Traditionally, the Kaminuriak Herd range extended from Baker Lake, NWT southward into northern Manitoba. During 1925-31 a railway was constructed from Churchill south to the Nelson River and parallel to the river itself. Only once prior to 1935 was the herd known to extend as far south as the Nelson River. Four years after construction the herd started to cross the railway and continued to do so until the herd began to decline during the 1950s. The decline is attributed to access resulting in over-harvesting by hunters, wolf predation and partial herd displacement. The authors maintain that the railway did not create a barrier effect.

Snohetta Herd

The Snohetta Herd comprises the wild reindeer that inhabit the Krustsho and Snohetta range in Dourefjell National Park, Norway. This population declined dramatically from over-harvesting, resulting in a significant reduction in range size. This coincided with the completion of the railway. During 1956, while the herd was expanding, reindeer began crossing the railway and highway and have continued to do so in recent times. The authors believe that the reindeer discontinued their migration across the railway prior to 1956 because of herd contraction, not construction of the railway. By 1960 the herd had substantially increased and was using all of its range.

The authors conclude that caribou have a high degree of resilience and are able to adapt to, within a certain degree, man's presence as long as hunting is controlled and space in the form of range size is not restricted. They found no convincing evidence from any of the eight herds investigated that habitat loss or habitat disturbance was a significant factor in altered productivity or adult mortality rates resulting in declines.

Letter to the editor of Arctic 37(3):293 from K. R. Whitten and R. D. Cameron in response to Bergerud et al. 1984. The buffalo of the north: caribou (Rangifer tarandus) and human development.

This letter provides comments from observations made in the paper, "The buffalo of the north: caribou and human developments" by A. T. Bergerud et al. (1984). Whitten and Cameron believe that responses in individuals and groups can be extropolated to the population level. Whitten and Cameron indicate that Bergerud et al. (1984) criticized correlation reasoning and yet used it in their paper. A number of technical errors are addressed. Whitten and Cameron agree with the overall conclusion of the paper.

Letter to the editor of Arctic 37(3):293 - 294 from D. R. Klein and R. G. White in response to Bergerud et al. 1984.

Klein and White discuss the paper prepared by Bergerud et al. (1984). The authors believe the paper does not meet its objectives, particurarly as it relates to reasoning by correlation. Klein and White feel that Bergerud et al. (1984) discredit the use of correlation reasoning but continue to use it. Numerous technical problems also are addressed. Klein and Whitten conclude that it would be wiser to take a conservative approach than to place unwarrented risk on the wildlife.

Letter to the editor of Arctic 37(3): 294 - 295 from A. T. Bergerud, R. D. Jakimchuk and D. R. Carruthers in response to letters written by Whitten and Cameron and by Klein and White regarding the paper entitled, "The Buffalo of the North".

Bergerud et al. (1984) address cristicisms from Whitten and Cameron (Arctic 37(3):293) and Klein and White (Arctic 37(3): 293-294). Bergeurd et al. (1984) suggest that they attempted to present a balanced point of view. Bergerud et al. (1984) feel that the authors of both letters question some of the paper's issues and yet fail to substantiate their viewpoint. In addition, they feel comments made about the use of correlative reasoning were incorrect, and make the distinction between inductive and deductive reasoning. Bergerud et al. (1984) believe that people have been too hasty in forming opinions about this paper, and conclude that the problem lies in the different views people have of nature and its ability to adapt.

Letter to the editor of Arctic 38(2) 154 - 155 from F. L. Miller and A. Gunn in response to Bergerud et al. 1984. The buffalo of the north; caribou (Rangifer tarandus) and human development.

This letter expresses concerns about the paper entitled, "The Buffalo of the North: Caribou and Human Development", by Bergeurd et al. (1984). Miller and Gunn express concern

about how this paper will be interpreted by biologists, laymen and individuals associated with development. In addition, Miller and Gunn feel this paper polarizes views (e.g., wildlife managers and resource developers) and places unwarrented risk on caribou by aiding resource developers in avoiding environmental issues and mitigation measures. It is felt that the evidence provided by the Bergerud et al. (1984) may be used to circumvent concerns identified in earlier research.

Letter to the editor of Arctic 38(2): 155 - 156 from A. T. Bergerud in response to F. L. Miller and A. Gunn's rebuttal letter re: The Buffalo of the North: caribou (Rangifer tarandus) and human development.

A. T. Bergerud responds to the letter by Miller and Gunn (Arctic 38(2): 154 - 155). As a scientist, Bergerud believes that impacts on caribou must be examined in an unbiased manner.

Letter to the editor of Arctic 38(2): 156 from R. D. Jakimuchuk in response to F. L. Miller and A. Gunn's letter of rebuttal re: The buffalo of the north: caribou (Rangifer tarandus) and human development.

Jakimuchuk disputes accusations made by F.L. Miller and A. Gunn who questioned the paper entitiled "The buffalo of the north: caribou (Rangifer tarandus) and human development.

Cameron, R.D. and K.R. Whitten. 1980. Distribution and movements of caribou in relation to the Kuparuk Development area. Second Interim Report. Alaska Department of Fish and Game. Juneau, Alaska. 35 pp.

The calving ground of the Central Arctic Caribou Herd was surveyed in June 1979 by helicopter and from the West Sak Road by truck from June to August 1979. Approximately twice the number of caribou were observed on the calving ground in 1979 than in 1978. This is attributed to natural fluctuations of pregnant cows using the area.

There was a low occupancy rate of parturient and postpartum caribou within or adjacent to the Prudhoe Bay Complex, which suggests avoidance of the complex by cow/calf pairs. However, avoidance of the roads outside the complex during 1979 was not detected. Estimated calf percentages from the West Sak Road were similar to regional levels.

Caribou displayed a preference for using river drainages when moving from one area to another. As of 1980 there were no "major abnormalities" in caribou summer distribution near the Kuparak Development. Cameron and Whitten suggest that the level of development in the Kuparak Development area is presently below the caribou's threshold of disturbance and does not appear to be causing determental impacts. Recommendations include mitigation measures to minimize disturbance during resource development.

Cameron, R.D. and K.R. Whitten. 1982. Effects of the Trans-Alaska Pipeline on caribou movements. Project Progress Resport Vol. 6. Alaska Department of Fish and Game, Juneau, Alaska. 12 pp.

Caribou distribution and composition along the Dalton Highway, Alaska have been monitored since 1975. Observations of caribou movements along the highway show abnormal distribution resulting in a significantly lower occupancy rate. Calf percentages during 1975 were similar to the regional level, but from 1976 to 1978 percentages were substantially lower. A marked increase in calf percentages was noted in 1979 followed by a decrease in 1980. Calf percentages were approximately 10% of the regional values between 1977 and 1980. This low calf percentage is interpreted as avoidance behaviour of the road by cow/calf pairs. Based on their observations, Cameron and Whitten suggest that an inverse relationship exists between highway traffic and caribou sightings from the road. Despite these conclusions, the Central Arctic Herd continues to be productive. This has been attributed to the mild winters and low predation rates during previous years.

Cameron, R.D. 1983. Issue: caribou and petroleum development in arctic Alaska. Arctic 36(3): 227-231.

This review paper examines the potential conflicts between petroleum development and caribou and their habitat. The area in question is the Arctic Slope in Alaska. The Western, Arctic, Teshekpuk, Central Arctic and Porcupine caribou herds occupy this region during some period of each year. If all of the potential oil bearing land is developed on the North Slope, approximately 12.5 million ha (60% of the area) would be affected. However, it is unlikely that developments over this vast area would be simultaneous. Some of the issues examined include: parturient and postpartum caribou and their avoidance/acceptance of these developments; displacement of herds; and, caribou movements in response to insects in relation to development.

Major oilfields create a significant threat to caribou and their habitat. This is augmented by connecting roads, pipelines, and associated traffic (aerial and land-based) which intensify the impact. Maintaining adequate caribou habitat (e.g., size and diversity) should be a principal goal. The author states that many of the industrial activities with undesirable effects, (e.g., helicopter overflights and ATV activity) can be mitigated. Appropriate regulations, guidelines, and company operating policies would have to be strictly followed if mitigative measures are to be effective.

Carruthers, D.R. and L.G. Sopuch. 1982. Characteristics of caribou trails in relation to an old, unplowed seismic line on winter range, January and February, 1982. Renewable Resources Consulting Services Ltd. Sidney, British Columbia. 47 pp.

The characteristics of caribou trails in relation to old seismic lines on a caribou winter range, northwest of Great Bear Lake, were examined during January 1982. All caribou trails whichbisected seismic lines within a 32 km radius of field camps were plotted on topographic maps. Stations were established along the caribou trails on each side of the seismic line and were examined for a distance of 100 m along the approach and departure paths. The following conditions were recorded; azimuth of seismic line, azimuth between stations, snow depth, snow hardness, caribou sign, dominant vegetation, and distance between stations.

The 19 caribou trails encountered over a 12 day period were all located on one seismic line. The results showed that 17.1% of the caribou trails traversed the seismic line where coniferous forest was the dominant vegetation. Caribou preferred (47.7%) to cross lines in coniferous forest with a canopy cover greater than 60%. Habitat associated with lakes and fens accounted for 26.3% of crossings.

Carruthers found that approach and departure paths remained in similar habitat and showed little variance. The orientation between approach and departure of caribou trails did not vary

significantly. Nor was there any change in orientation of trails between the forest and non-forested habitat.

In general, snow depth was uniform along both segments of each caribou trail. The deepest snow was found in the forested areas. The snow hardness was generally less in the forested areas. Data suggest that the variability in snow hardness had little effect on the distribution of caribou trails.

The frequency of caribou sign (pellet groups, urination, and feeding craters) did not change in relation to the proximity of seismic lines.

Based on Carruthers' observations, seismic lines apparently did not cause caribou to deviate significantly from their direction of travel. Caribou did not appear to use the corridors for travelling. Evidence suggests that Bluenose caribou herd behaviour was not altered by encountering an old seismic line.

Curatolo, J. A. and S. M. Murphy. 1986. The effects of pipelines, roads and traffic on the movements of caribou, Rangifer tarandus. Can. Field-Nat. 100(2): 218-224.

Caribou, Rangifer tarandus, from the Central Arctic Caribou Herd were studied near the Kuparuk and Ugnuravik rivers, Alaska. The authors determined the frequency at which caribou crossed pipelines and roads, how pipeline height influenced selection of crossings, and whether buried sections of the pipeline were preferred to elevated segments.

Caribou movements were influenced by insect activity. During high levels of insect harassment, primarly mosquitos and oestrid files, caribou exhibited directional and non-directional movements, respectively. When mosquitos were present, caribou travelled north to the coast in search of relief. Caribou moved south, away from the coast, when mosquito activity subsided. When oestrid flies were present, the caribou sought relief in the shade of the pipeline or escaped by running short distances. Repeated pipeline crossings were common by individuals trying to escape the flies.

Differences in crossing frequencies were not significant between control sites and experimental sites with pipelines or roads (with low levels of vehicular traffic). Lower crossing frequencies were noted for pipeline/road sites where a high level of vehicular traffic (30 vehicles/hour) was a factor. At a pipeline/road crossing site, caribou often hesitated for up

to 10 minutes before crossing. If vehiclular traffic was encountered caribou delayed or abandoned the crossing. The authors suggest that caribou on the oilfield respond to two types of stimuli: structures which may resemble concealing habitat, and moving vehicles which may resemble predators. Data suggests that caribou readily crossed single structures such as pipelines or roads; however, when caribou encountered multi-structures (e.g., pipeline-road combinations), the frequency of successful crossings decreased. This suggests that the separation of pipelines and roads would facilitate crossings.

The pipeline height examined throughout the study ranged between 152 - 432 cm. Caribou did not appear to select any particular heights when crossing; a minimum height of 150 cm appears to be adequate for caribou. Individuals did show a perference for ramps when crossing. However, the authors doubt that ramps would buffer against the effects of traffic or the impact from construction. They may useful during periods of low vehicular traffic activity.

Curatolo, J.A., S.M. Murphy and M.A. Robus. 1982. Caribou responses to the pipeline/road complex in the Kuparuk Oil Field, Alaska, 1981. Alaska Biological Research. Fairbanks, Alaska. 64 pp.

The response of caribou to the Kuparuk Oil Field, Alaska was monitored from 22 June to 5 August 1981. This area lies within Alaska's North Slope and contains habitat used by the Central Arctic Caribou Herd. During this study, a total of 5,229 caribou were classified according to sex and age. The cow/calf ratio was 75 calves per 100 cows.

Caribou were observed under two circumstances: pipeline site and pipeline-road site. The first site consisted of an elevated pipeline between 152 and 432cm above ground level (agl). The pipeline-road site consisted of an elevated pipeline between 152 and 279cm (agl) located adjacent to a gravel road.

Generally, caribou which encountered the gravel road showed no signs of distress; however, they did display minor behavioural changes. Some individuals fed on vegetation growing on the road embankments. Road useage changed littled between mosquito and olstrid fly season. However, during the oestrid fly season, caribou sought the gravel road and spent significantly more time travelling and/or standing on it.

Caribou responses to the pipeline-road consider (without traffic) were: 44% demonstrated no reaction, 19% exhibited

"mild" reaction, 16% showed "moderate" reaction, and 22% demonstrated "severe" reaction. Most "no reaction" or "mild" reaction encounters occurred during the oestrid fly season when animals used gravel pads, roads, and the shade created by the pipeline.

The reactions of caribou to the pipeline-road site with traffic present were: 28% exhibited a "mild" reaction, 16% showed a "moderate" reaction, and 56% demonstrated a "severe" reaction. All crossing caribou showed some reaction to traffic when present. During the mosquito season, caribou sometimes paralleled the road or pipeline then crossed and moved away from the area when traffic was encountered. During oestrid fly season, caribou often stood in the shade of the pipeline, on gravel pads or on the road. When traffic approached, caribou usually reacted by running ahead of the vehicle or off to one side for a short distance; however, they often returned to the road.

Caribou showed a strong preference for crossing at over-passes, presumably because of the lack of or a reduced visual barrier.

Crossing was often initiated by one individual. Caribou response to the pipeline and/or road altered according to the degree of insect harassment. Caribou took advantage of the pipeline and/or road to obtain relief from insect harrassment. Moving vehicles appeared to have the most significant impact on caribou using the area.

Dau, J. R., and R. D. Cameron. 1986. Effects of a road system on caribou distribution during calving. Pages 95 - 101 in Proceeding of the Fourth International Reindeer/Caribou Symposium, Whitehorse, Canada, 1985. Special Issue No. 1. 374 pp.

During the winter of 1981 - 82, a 29 km gravel road was constructed by CONOCO Inc. near Milne Point, Alaska. In the winter of 1984 - 85, a 300-person housing facility and a single pipeline (1.8 m agl) was constructed adjacent to the road. This initial phase of petroleum development is situated in the centre of the Central Arctic herd calving area.

This study examines the effects of a road, pipeline, and associated facilities on maternal cows and general caribou distribution. Annual surveys were conducted during the calving period for four years prior to (1978 - 81) and for four years following road development (1982 - 85). The effects of the road, pipeline, and associated facilities were analysed by comparing data from these two periods.

The authors found fewer caribou in the area of the road system after construction than before construction. The linear relationship between caribou densities and distance from the road varied significantly from 1978 - 81 and 1982 - 85. Data for 1978 - 81 showed no linear relationships between the total number of caribou or the number of calves in the proximity of the road. But during 1982 - 85, a linear relationship did exist among the total number of caribou and the number of calves and the proximity of the road. The density of maternal females within 6 km of the road declined following construction of the road.

A postive correlation was found between the density of maternal groups and the road which was not apparent before 1981. No significant correlation existed for non-maternal groups during both periods.

The authors state that this is the first study to examine, systematically and quantitatively , the effects of petroleum development within a high-use calving area. The study suggests that a local displacement of maternal females occurred in response to the road, pipeline, and related activities. Despite this impediment, the Central Arctic Herd population continues to increase.

Donihee, J. and P. A. Gray. 1982. A review of road related wildlife problems and the environmental management process in the north. Department of Renewable Resources, N.W.T. Information Report No. 2. 20pp.

Although road development in the north is relatively new, pre-development data on wildlife abundance and distribution is virtually non-existent. Recognition of this problem resulted in this paper. The objectives of this report were to:

1. Provide a brief review of the published literature relating to road/wildlife impacts;

2. Discuss impact reduction strategies and how they fit into the overall planning process and review some case histories; and

3. Provide some recommendations towards solving the problems mentioned above.

Habitat loss through road construction affects different species to different degrees. For example the authors cite numerous reports for mountain caribou (Rangifer tarandus caribou) and raptors and how they may be more sensitive than barren-ground caribou (Rangifer tarandus groenlandicus) because of their spatial requirements.

Disturbance to wildlife by road development is a long-term impact. It begins with the survey crews and

continues beyond the completion of the project. These effects on wildlife behaviour are not well understood at the population level or individual level. This problem is augmented by the lack of pre-development studies. The authors site reports which examine one of the most serious effects of roads on wildlife, increased hunting access. Some of the reports reviewed showed that there were declines in wildlife populations in areas near settlements in the NWT. Additional problems potentially exist from work crews illegally taking wildlife.

Impact reduction stragegies should be incorporated into all phases of development (design, construction, operation and maintainance). Certain wildlife requirements (e.g., spatial needs) should be met throughout the development stages. The timing of operations is also critical in order to avoid negative impacts on wildlife during sensitive periods of the year. Operational codes should be incorporated into the plan to buffer impacts.

Donihee and Gray focus on two major problems, road planning and the techniques used in studying the impacts. From the road planning perspective, environmental assessment must start from the beginning. Preliminary wildlife studies should be conducted before development takes

place. These studies should include an interdisciplinary approach which deal with any data gaps. The environmental assessmental should be intergrated throughout the process.

In studying behavioural and physiological reactions to linear developments biologists require standardized research techniques. Unfortunately in the past techniques used in examining impacts have varied tremendously. This lack of standardization has resulted in incompactable data. Standardized techniques need to be developed.

Long-term research on how roads effect wildlife will assist in the development of an effective environmental assessment process. This coupled with mitigative measures and regulated access will hopefully buffer any negative influences roads have on wildlife.

Eide, S. H., S. D. Miller and M. A. Chihuly. 1986. Oil pipeline crossing sites utilized in winter by moose, Alces alces, and caribou, Rangifer tarandus, in southcentral Alaska. Can. Field-Nat. 100(2):197 - 207.

The Trans-Alaska Pipeline parallels the Copper River and passes through the Copper River Basin. It intersects important moose and caribou migration routes. Special crossings were constructed to facilitate free or unobstructed movement of large ungulates. These special-designated big game crossings (DBGCs) consist of elevated segments of pipeline exceeding 3.0 m in height and buried sections of pipe. The objective of this study was to evaluate the effectiveness of these special crossings along a 145 km section of pipeline.

The analysis of the data is confounded because the DBGCs were not located randomly along the pipeline. In areas where caribou traditionally migrated, extensive sections of pipeline were buried. Consequently, intensive use of such areas would not necessarily indicate a selection for these types of crossings, but rather continued use of historic routes. The methodology employed here did not facilitate the determination of deflection behaviour resulting from the pipeline. However, anecdotal observations on deflection were recorded on a few ocassions from a fixed-wing aircraft.

The results did not substantiate whether or not the DBGCs assisted moose and caribou in crossing the pipeline. Data revealed that caribou selected buried sections and sections of pipeline higher than 2.4 m and avoided elevated sections of

pipeline less than 2.1 m in height. Moose did not demonstrate any selection for pipeline characteristics based on pipe height or length of buried sections when crossing.

The Nelchina Caribou Herd has increased since 1977 despite any impediments the pipeline may have created. The moose-population in the area appears to be unaffected by the pipeline, which is substantiated by the results of aerial surveys. It appears that the creation of moose and caribou crossings are adequate.

Elison, G. W., A. G. Rapport and G. M. Reid. eds., 1986. Report of the caribou impact analysis workshop, Arctic National Wildlife Refuge, November 19 - 20, 1985, U. S. Fish and Wildlife Service, Fairbanks, Alaska. 39pp.

This paper documents the results of a workshop designed to simulate and analyze the effect of large scale development on caribou range. A hypothetical development scenario was created on the coastal plain of the Arctic National Wildlife Refuge. Participants addressed major issues, including carbiou/ development interactions; effects of development on calving grounds and insect relief habitat; and, the effect of development traversing migrational routes. Given this scenario, participants agreed that there would be a decline or displacement of the Porcupine caribou herd.

Fourteen issues were addressed:

1) Displacement of the Porcupine caribou herd from calving areas.
2) Hunting as an impedement to habituation of caribou to the developed area.
3) Correct design and installation of ramps to facilitate caribou movements.
4) Since the initial construction phase creates the greatest potential for displacement, time and area closures should be implemented for surface and air traffic during critical times (e.g., calving period).

5) Centralization of facilities to minimize habitat disturbance.

6) Separate roads and pipelines to reduce avoidance behaviour.

7) Workshop participants did not know to what degree the caribou would habituate to development. Cows with calves are expected to be more sensitive to development than bulls or cows with no calves.

8) Direct habitat loss would be minimal as long as facilities were centralized and not located in key areas such as calving grounds.

9) Disturbance to caribou from development could be minimized by limiting the access of all non-essential people and vehicles to critical areas.

10) A development/mitigation plan should be developed to avoid redundant facilities.

11) Introduce and education program, and provide an on site Monitor.

12) Mitigate same impacts through proper pipeline construction. Pipelines should be buried whenever possible or otherwise elevated on vertical supports.

13) Although direct habitat loss would be minimal, areas no longer in production could be rehabilitated. Gravel from abandoned sites could be reused thus lessening the need to eliminate additional habitat for new gravel.

14) The workshop participants would not address the cumulative effects of development to wildlife on adjacent land (e.g., the Outher Continental Shelf, private lands, State of Alaska waters, and State land west of the Canning River).

Fancy, S.G. 1983. Movements and activity budgets of caribou near oil drilling sites in the Sagavanirktok River floodplain, Alaska. Arctic 36(2): 193-197.

The movements and activity budgets of caribou on the lower Sagavanirktok River Delta, near the Prudhoe Bay oilfield, were monitored between 1 July and 10 August 1981. An experimental site and a control site were established. The experimental site was 9 $km^2$ and encompassed two drilling sites, raised gravel roads, and elevated pipelines (approximately 2 m agl). Both rigs operated during the study. The control site and the experimental site were similar in size and environmental parameters. Two abandoned winter roads and one abandoned drilling pad were present on the control site.

During the course of the study, 1,035 caribou were observed on the experimental site and 998 on the control site. The mean rates of movement during low and high insect activity were similar on both sites for each level of insect harassment. Caribou moved significantly faster during periods of mosquito and/or oestrid fly harassment than did unharassed individuals. During high mosquito activity, the predominant direction of travel of the caribou was towards the coast, while during oestrid fly activity, caribou movements were not oriented in any particular direction. The predominant direction of caribou movements on both grids was northeast, which paralleled the river. Because of the predominant direction of travel, most caribou crossed both grids.

Although insect harassment had a significant effect on caribou activity, the time caribou spent feeding and lying did not substantially differ between the sites during low and high levels of insect activity.

Most caribou encountering the pipeline traversed it by "quickly trotting underneath". However, under certain conditions caribou appeared to benefit from the drilling structures by standing underneath pipelines or beside buildings. The author believes that this may provide relief from insects and/or heat stress.

During 1980, calf percentages on both sites were similar to the regional level. However, during 1981 calf percentages on both sites were less than half the regional level. Fancy believes that this was due to a natural annual fluctuation in the number of cow/calf pairs using the area and not a result of industrial development. He does note that cow/calf pairs were avoiding the area, but suggests that his results be interpreted cautiously because the test sites are not typical of drilling operations found elsewhere in the Prudhoe Bay oilfield.

Gunn, A., R. Glaholt, R.L. Miller and K. Jingfors. 1983. Caribou behaviour, range use patterns and short term responses to helicopter landings on the Beverly calving ground, N.W.T., 1982. N.W.T. Wildl. Serv. File Rep. No. 30. 126 pp.

During 1981 and 1982 Gunn et al. (1983) recorded the behaviour of disturbed and undisturbed cow/calf pairs on the Beverly Herd calving grounds. Activity budgets for 1982 were similar to those observed in 1981. The rates of nursing and attempted nursing were greater in 1982. Part of the experiment involved subjecting caribou to helicopter overflights. Unfortunately, a large portion of the sample left the area during the disturbance. Consequently, observations of post-disturbance behaviour were not possible. However, some observed differences suggested an increase of cows and calves walking, trotting and galloping during the disturbed phase (post-disturbance). The rate of nursing decreased during the disturbance phase. In a previous study conducted on Peary caribou, Miller and Gunn (1979)[1] showed that cow/calf pairs (as opposed to bulls and juveniles) were most responsive to helicopter disturbance.

The long-term effects to the population and short-term consequences to cow/calf pairs were beyond the scope of this study. However, Gunn et al (1983) concluded that exposure to helicopter landings cause "disruption of ongoing maintenance activities" and elicit responses conducive to displacement from the immediate area.

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[1]F.L. Miller and A. Gunn. 1979. Responses of Peary caribou and muskoxen to helicopter harassment. Can. Wildl. Serv. Occas. Pap. No. 40. 90pp.

Gunn, A. 1984. A review of research on the effects of human activities on barren-ground caribou of the Beverly and Kaminuriak herds, Northwest Territories. N.W.T. Wildlife Serv. File Report No. 43. 66 pp.

This report describes: the Caribou Protection Measures; research on the effects of human activities on caribou on various calving grounds throughout North America; factors influencing the selection of three barren ground caribou calving grounds in the Northwest Territories; behaviour and range use patterns of calving Beverly caribou on the calving grounds and water crossing sites.

Data suggest that traditional calving grounds are not chosen solely according to biophysical characteristics such as topography, snowmelt patterns, vegetation or predators. Gunn (1983) suggests that selection may be based, in part on traditional use. The location of calving grounds do not precisely overlap and vary annually. Gunn attributes the slight annual variation in the distribution of the calving grounds to environmental conditions, (e.g., snow conditions).

Range use by Beverly caribou on the calving ground in 1981 was primarily confined to lichen uplands. After calving, lichen uplands were still used for bedding, but the more succulent vegetation found in the meadows and dwarf shrub ranges were preferred for foraging. Similar results were found in 1982, except that meadow range types were preferred for bedding as well as foraging during the post-calving period.

During the post-calving period, caribou on the Beverly calving ground were exposed to 16 experimental helicopter landings. These landings occurred approximately 920 ± 650m (SD) from caribou groups. Caribou responded by moving away from the helicopter at lease 1 km.

Available data and circumstantial evidence suggests that caribou persistantly use specific water crossing sites.

This report includes a brief review of studies examining the effects of human activities on caribou on other calving grounds. The author stresses that any conclusion should be interpreted cautiously since each population is exposed to different environmental factors which affect how they respond to stimuli. Emphasis is placed on the importance of cumulative baseline data resulting from a repeatable study design.

Hanson, W.C. 1981. Caribou (Rangifer tarandus) encounters with pipelines in northern Alaska. Can. Field-Nat. 95(1): 57-62.

With the development of oil fields on the North Slope of Alaska, concerns have been expressed about potential disruption of caribou movements. The objectives of this study were to examine the behaviour of caribou encountering a raised berm associated with a gas pipeline.

At the Prudhoe Bay Test Site, an experimental berm and pipeline (610 m in length) were constructed to simulate an actual development. The berm height varied between 0.8 and 1.7 m, and consisted of residual material and gravel, with a 3:1 slope on the embankment. The pipeline passed through a control building adjacent to an ice road.

During the 1971-1973 study period, most caribou/berm encounters occurred where berm heights were appreciably lower than 1.7m, the volume of vehicular traffic was less, and the generator noise was less. Animals readily crossed berms but were wary of deflection poles, thermocouple planes, and boardwalks; they usually avoided these structures. Caribou were observed using breeze-swept berms during the summer to escape insects. The author believes that caribou seeking relief from insects are attracted to these berms and once on them are reluctant to leave them. An important factor in the caribou's acceptance of these berms may be linked with the exotic grasses which were planted on the embankment of the berms. Caribou may have preferred these grasses to normal forage.

All encounters involved individuals or small bands of caribou on a experimental test site. It is unknown how an actual pipeline that stretches for hundreds of kilometres would affect a population of caribou. Data suggest that caribou readily traversed berms less than 1.2 m agl. While berms of a greater height had the pronounced impact of deflecting caribou.

Horejsi, B.L. 1981. Behavioural response of barren ground caribou to a moving vehicle. Arctic 34(2): 180-185.

Data were collected during 1976 and 1977 on the behavioural response of caribou to a moving vehicle. The tests were conducted on the Dempster Highway, Yukon Territory, using a 3/4 ton pickup truck. During 34 of 36 observations, the vehicle was moving at a speed greater than 56 km/h. The remaining two observations involved encounters while the truck was parked. The following conditions were noted during each encounter: size and composition of the group; duration of observation from initial encounter until the caribou could no longer be observed or did not appear to respond to the truck; response of the animal to the truck; group dispersion; estimated distance between truck and group upon initial sighting and the distance between both when flight behaviour was observed; distance of closest approach (applying to caribou which approached the truck while it was parked); flight duration; and habitat.

In general, caribou displayed a negative response (i.e. displacement behaviour to a moving vehicle). These responses were interpreted as anxiety and fear, and often resulted in short, strenuous flight behaviour. An individual's response appeared to be related to the vehicle's rate of approach. Animals would withdraw from the truck until the threat was reduced to near zero. The author speculates that caribou might avoid the Dempster Highway if traffic increased.

Klein, D.R. 1980. Reaction of caribou and reindeer to obstructions - a reassessment. E. Reimers, E. Gaare, and S. Skjenneberg (eds.), Proc. 2nd Int. Reindeer/Caribou Symp., Roros, Norway, 1979. Part B pages 519 to 527.

This paper provides a review of disturbance and its effect on caribou and reindeer. With increased human activity in the north, caribou are exposed to new, unfamiliar stimuli. Some conflicting viewpoints have been expressed in the literature. Klein (1980) believes that this is a result of genetic differences in behaviour exhibited between populations of Rangifer. Caribou reactions to disturbance can be summarized according to the source of the disturbance: linear features; type and degree of human activity (e.g., vehicles on roads); time of year of impact; herd composition; and, the duration of the impact. Klein suggests that caribou and reindeer are more apt to become habituated to a disturbance if they are exposed to it on a continuous or frequent basis rather than a seasonal one.

Miller, F. L. 1985. Some physical characteristics of caribou spring migration crossing sites on the Dempster Highway, Yukon Territory. Pages 15 - 21 in Martell, A. M.; Rusell, D. E. eds. Caribou and human activity. Proc. 1st North Am. Caribou Workshop, Whitehorse, Yukon, 28 - 29 Sept. 1983. Can. Wildl. Serv. Spec. Publ., Ottawa.

The Dempster Highway spans the winter range of the Porcupine Caribou Herd (Rangifer tarandus granti) in the Yukon Territory and traverses the spring and fall migration routes of the caribou. In April 1981 the author examined how this road affects the migration behaviour of caribou. Barren-ground caribou have evolved in the absence of man-made linear structures; therefore, the author's working hypothesis was that caribou crossed the highway based on visibility and the road's physical features in the absence of traffic and other human activities.

Caribou trails which crossed the Demspter Highway between km 100 to 371 were carefully examined. All relatively fresh trails were classified into two catgories, spring migration path or a non-migrational, foraging trail. Measurements of the caribou trails were taken where warranted. These measurements included: depth of snow, sinking depth of caribou trails, angle of inclination adjacent to road, length of each slope, and an estimation of visibility along the caribou's approach and departure. Other pertinent notes included useage of gravel ramps by caribou.

Most of the caribou trails (88.1%) crossing the highway were classified as migration trails and originated from the frozen Blackstone and Ogilvie rivers. These trails directly crossed the road and continued northward. Caribou extensively foraged adjacent to the highway on all migration trails. The balance of the caribou crossings (11.9%) were completed by non-migrating, foraging caribou.

Only 29.0% of all the caribou trails crossing the Dempster Highway had similar terrain or cover type along their approach and departure, while 71.0% of the terrain or cover type was different between the approach and departure. Caribou showed a strong affinity for using gravel ramps, when encountered, on their approaches. The author goes on to discuss the openness and visibility associated at some of the caribou crossings. Miller suggests that since the vertical height of the road creates a blind spot, good lateral visibility is important.

This study shows only the short-term effect of the Dempster Highway on the migrational behaviour of the Porcupine caribou in the absence of traffic. Other factors which could effect caribou movements include the presence of wolves and humans (e.g., photographers).

Miller, F.L. and A. Gunn. 1981. Play by Peary caribou calves before, during and after helicopter harassment. Can. J. Zool. 59: 823-827.

Between 23 June and 16 August 1977 play behaviour by Peary caribou calves was observed on Prince of Wales Island, NWT.

On 20 occasions 93 bouts of play were observed. Calf behavior was observed and recorded during three phases: the undisturbed phase, the harassed phase, and the recovery phase. The undisturbed phase comprised observations made prior to helicopter or observer disturbance. The harassment phase involved helicopter overflights, during which information was collected on the duration of actual passes and intervals between them. The recovery phase was the period of observation following helicopter overflights.

The greatest response of play behaviour exhibited was observed during the harassment phase. The recovery phase had the second highest incidence of play behaviour followed by the undisturbed phase. Out of 30 bouts of play during the harassment phase, 26 bouts involved caribou that were bedded or foraging. Calves did not exhibit any form of alarm or escape behaviour. The authors could not determine if these calves were under stress. The authors suggest that the calf-play behaviour was triggered by the harassing stimuli as a result of increased levels of excitation. The calves displayed no escape or alarm behaviour. This was attributed to the lack of cues exhibited by the adults. It is suggested that when calves were exposed to

helicopter overflights, which was a new stimulus to them, they responded first with increased levels of energy and were ready to respond according to the adults' responses. When the adults gave no "social signals" to respond, calves released their elevated energy levels in the form of play. The authors concluded that play behaviour may be a sign of stress rather than an indication that all is well. Consequently, calf play behaviour should not be used to indicate well-being during or shortly following exposure to harassment.

Mychasiw, L. 1985. Caribou protection measures: a case history. Pages 47 - 51 in Martell, A. M.; Rusell, D. E. eds. Caribou and human activity. Proc 1st North Am. Caribou Workshop, Whitehorse, Yukon, 28 - 29 Sept. 1983. Can. Wildl. Serv. Spec. Publ., Ottawa.

This paper summarizes the Caribou Protection Measures (CPM) which were implemented in 1978. The protection measures are disigned to mitigate potentially disruptive land-use activities to the Beverly and Kaminuriak barren-ground caribou (Rangifer tarandus groenlandicus) for all areas used by the caribou during migration, calving and post-calving periods. In effect the CPM are operating guidelines for land use permit holders who are regulated by the Indian and Northern Affairs and monitored by the NWT Wildlife Service.

The objectives of the Caribou Protection Monitor are to:

1. Advise land-use inspectors on caribou matters.
2. Map caribou movements and activities during spring migration, calving and post-calving periods.
3. Evaluate the protection areas boundaries in relation to the position of animals and identify important habitat.
4. Observe and plot human activities in relation to the position of animals and advise land-use inspectors of potential problems.

Each year the caribou are monitored by aerial reconnaissance. The Monitor's observations and recommendations are submitted to the land-use inspector where

by land-use permits are issued or withheld.

The effectiveness of the protection measures can be assessed by the number of permits which have posponed operations over the passed years. During 1981 and 1982 seven land-use operations were deferred which shows that the controls have some effect in mitigating potentially negative activities on caribou.

Penner, D.R. and J.A. Duncan. 1983. Monitoring of a geophysical exploration program and its effect on wildlife, particularly woodland caribou, near Manning, Alberta. Report prepared for Mobil Oil Canada, Ltd. by McCourt Management Ltd. 137 pp.

This study was initiated to examine the effects of geophysical exploration on a small woodland caribou population near Manning, Alberta.

A total of 54 observations of caribou encountering seismic lines were completed. They are summarized as follows: 9% were deflected, 26% followed the seismic lines, and 65% crossed the seismic lines.

The average height of berms at crossing points were consistently lower than in adjacent segments where crossing did not occur. Berm height appeared to be more of an impediment than berm width.

The authors found that caribou were not "immediately" displaced by seismic operations. There were some notable shifts in range distribution, but this is not attributed to the seismic operation. Seismic lines and slash berms influenced caribou movement across the lines. There were no demonstrable effects on the caribou as a result of this seismic program. Short-term impacts were considered negligible, and indirect long-term impacts in the form of increased access for hunters are a potential problem.

Smith, W.T. and R.D. Cameron. 1983. Responses of caribou to industrial development on Alaska's Arctic Slope. Acta Zool. Fenn. 175: 43-45.

The distribution and composition of the Central Arctic Herd was monitored in relation to pipeline construction and operation near Prudhoe Bay, Alaska. Surveys were conducted using a truck along a network of gravel roads. A total of 1,694 caribou were observed within or adjacent to the oilfield complex. Cow/calf ratios averaged 10% which is substantially lower than corresponding surveys which yielded estimates of 23% calves.Data show a lower cow/calf ratio within or adjacent to the industrial complex. This is interpreted as avoidance behaviour by cow/calf pairs. These findings are consistent with previous reports and show the sensitivity of caribou to industrial development. The authors state that the linear features and facilities associated with the Prudhoe Bay Complex create an impediment to caribou movement and affect herd composition.

Smith, W.T. and R.D. Cameron. 1985. Reactions of large groups of caribou to a pipeline corridor on the arctic coastal plain of Alaska. Arctic 38(1): 53-57.

Two large groups of caribou were observed attempting to cross an elevated pipeline in the Kuparuk Development Area near Prudhoe Bay, Alaska. Data were collected during two field seasons, 1981 and 1982. Caribou groups were observed from the road and great care was exerted to minimize observer influence. An important external factor affecting caribou was mosquito harassment. Mosquito harassment coincided with caribou crossing attempts and should be recognized as an element in crossing success.

The 1981 data comprises 917 caribou observations; 46% of the caribou eventually crossed elevated sections of pipeline in 26 separate attempts; 13% crossed buried sections of pipeline in two attempts; and, 22% travelled parallel to the pipeline for a least 32 km without crossing. The remaining 19% travelled out of view. Less than 60% of the caribou crossed the elevated pipeline.

The 1982 data comprises two separate observation periods. The first observation period consisted of 655 caribou over an 8 hour time span. During this period of time, 37 attempts were made at crossing the pipeline. Thirty-six of these attempts were made along elevated sections of the pipeline with only 23% being successful. Along a section of buried pipeline, 37% crossed in one attempt. The rest of the herd travelled out of sight

where subsequent behaviour could not be observed. Successful crossings accounted for 65% of the total number of caribou observed.

The second observation period was incidental, and consisted of 141 "bull/adults" which were unsuccessful in their attempts to cross the pipeline during periods of mosquito harassment.

Evidence suggests that large groups of mosquito-harassed caribou hesitated in crossing elevated pipelines. These findings are supported by previous studies. A greater number of successful crossings occurred along sections of buried pipeline than at sections of elevated pipeline. During both years, the majority of attempted crossings, by caribou paralleling the pipeline/road, occurred in conjunction with north-south oriented lakes. It is suggested that these lakes created a funnel effect and brought caribou closer to the barrier where local circumstances (e.g., topography or configuration of structures) dictated successful/unsuccessful crossings.

Energy expenditures increased for many caribou encountering the development. The authors suggest that well-designed, buried pipelines unaccompanied by roads or structures will mitigate many of the problems for caribou encountering pipelines.

Letter to the editor of Arctic 38(4): 344 from R. L. Newell, Ph. D. in response to W. T. Smith and R. D. Cameron 1985. Reactions of large groups of caribou to a pipeline corridor on the arctic coastal plain of Alaska Arctic 38(1): 53 - 57.

This response addresses the article entitled, "Reactions of Large Groups of Caribou to a Pipeline Corridor on the Arctic Coastal Plain of Alaska". Dr. Newell questions the lack of observations, statistical analyses, a testable hypothesis, and the study's methodologies. He believes that the results are weakly founded and the results should not be considered anything more than an anecdotal observation.

Letter to the editor of Arctic 38(4): 344-345 from W.T. Smith in response to Dr. Newell's letter of rebuttal.

This letter is in defence of the paper, "Reactions of Large Groups of Caribou to a Pipeline Corridor on the Arctic Coastal Plain of Alaska". The authors believe that Dr. Newell's comments are unfounded and that some of his conclusions are incorrect due to misinterpretation of the report. The letter goes on to clarify some of the points in the paper.

Valkenburg, P., R.D. Boertji and J.L. Davis. 1983. Effects of darting and netting on caribou in Alaska. J. Wildl. Manage. 47(4): 1233-1237.

Short and long-term effects of capturing caribou using darting and net gun techniques were examined. Between 1979 and 1982, 218 caribou were captured from different Alaskan herds. Some of the individuals captured were fitted with radio collars so that the impacts from handling could be monitored.

One hundred and sixty-three caribou were darted, nine of which died. Seven of the nine deaths were caused by the dart, while the remaining two deaths resulted from complications. Five of the seven deaths caused by the dart resulted from excessive dart velocity coupled with poor shot placement.

Fifty-five caribou were captured using a net gun technique. Seven of the 55 died during the netting procedure. An important factor in using the capture net is the size of the mesh and the presence of snow or soft ground to cushion the animal's fall.

The authors state that, independent of actual darting or netting, caribou rarely injured themselves when chased by a helicopter. It was also suggested that the capturing and handling of pregnant caribou had no apparent affect on the productivity or survival of calves. This statement is based on the fact that 84%

of the cows handled produced calves that same spring. There were no observed differences in productivity between darted and netted cows. They concluded that the greatest impact in the capturing of caribou resulted from the injuries incurred during darting or netting. The mortality rate and calf survival rate from being handled were not significantly affected.

Whitten, K.R. and R.D. Cameron. 1983. Movements of collared caribou, Rangifer tarandus, in relation to petroleum development on the arctic slope of Alaska. Can. Field Nat. 97(2): 143-146.

Between 1975 and 1978, 160 caribou from the Central Arctic Herd, Alaska were fitted with a visual collar or radio-collar. Animals were collared to determine their movements in relation to the Trans-Alaska Pipeline (TAP) and other petroleum development activities near Prudhoe Bay.

Caribou occupancy along the TAP corridor varied depending upon the proximity of the road. The proportions of caribou fitted with visual collars, which were resighted during the road survey, comprised 61% of the males and 35% of the females. The authors believe the 35% representation by females is significantly lower than regional levels. During aerial surveys conducted in the peripheral areas, composition comprised 39% of the males and 51% of the females. This comparison may not be entirely accurate and should be interpreted cautiously since collars affixed to males were attached to allow for neck expansion during the rut. Consequently some collars may have slipped off during the winter thus affecting the results. This conclusion is supported by the fact that most resightings of bulls occurred within the first year, while cows were frequently spotted two and three years after collaring.

Resighting of caribou from the road clearly showed a higher proportion of bulls than cows, while resightings during aerial surveys in the peripheral areas did not show a significant ratio difference between sexes. These results are consistent with previous reports of cow/calf avoidance of the TAP corridor.

Of all the resighted bulls, 68% crossed the corridor while only 41% of all resighted cows crossed. Data show a greater useage of the TAP corridor by bulls. However, baseline data is insufficient to determine whether or not this ratio was similar before the pipeline and road were constructed.

Evidence shows that cows avoid areas of petroleum development, while bulls appear to be less wary. There was a reduced occupancy by cow caribou in the TAP corridor and consequently a reduced crossing rate. The authors show that the midsummer movements were disrupted by the Prudhoe Bay oilfield activites.

ACKNOWLEDGEMENTS

I wish to extend my gratitude to those individuals who assisted in the production of this report. First, I would like to thank Len Mychasiw for his advice, suggestions and numerous reviews. Next, I thank Jackie Bell and Sinni Tong for typing the report and for making numerous changes to the report on my behalf. Finally, thanks are accredited to Paul Gray for his review and suggestions on the report and Alison Welch for editing this report.